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Is the ideal approximation operator always "ideal" for a particular C/F splitting?

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Given a coarse grid, the ideal prolongation operator is defined by $\mathbf{P}_\star = \begin{bmatrix}\mathbf{W} & \mathbf{I}\end{bmatrix}^T$, where the weight matrix, $\mathbf{W} = \mathbf{A}_{FF}^{-1}\mathbf{A}_{FC}$, interpolates a set of fine grid variable (F-points) from a set of coarse grid variable (C-points), and the identity matrix, $\mathbf{I}$, represents the injection of C-points to and from the coarse grid (Falgout and Vassilevski, 2004). In this talk, we consider $\mathbf{P}_\star$, constructed from both traditional C/F splittings and C/F splittings corresponding to aggregates, for several challenging problems. We demonstrate the effects of the C/F splitting on the convergence and complexity of $\mathbf{P}_\star$. Finally, we argue that $\mathbf{P}_\star$ may be misleading in demonstrating the "ideal" nature of interpolation for a given C/F splitting by providing numerical evidence that hierarchies built using $\mathbf{P}_\star$ converge more slowly than hierarchies built from alternative prolongation operators with the same C/F splitting. This is important as we wish to minimize the number of levels in a multigrid hierarchy by using a small set of C points for which $\mathbf{P}_\star$ may have poor convergence.